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PATENT APPLICATION
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DOCUMENT SCANNING APPARATUS WITH
OVERSIZE DOCUMENT HANDLING CAPABILITY

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1 DOCUMENT SCANNING APPARATUS WITH
2 OVERSIZE DOCUMENT HANDLING CAPABILITY

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4 FIELD OF THE INVENTION

5 The invention claimed and disclosed herein pertains to apparatus for optically
6 scanning documents, and more particularly to methods and apparatus to allow such
7 document scanning apparatus to scan oversized documents.

8
9 BACKGROUND OF THE INVENTION

10 The present invention is directed towards document scanning apparatus. Such
11 apparatus are configured to optically scan an essentially flat document using an optical
12 scanning device. The optical scanning device generates a stream of signals as the
13 document is scanned. The signals, typically in an analog form, can then be converted
14 into a digital form using known analog-to-digital conversion techniques. The resulting
15 digital signals collectively comprise a representation of the scanned portion of the
16 original document, and can be stored as a digital file or processed to generate a copy or
17 a displayed image of the original document. Further, the digital document file can be
18 further processed to modify the digital representation of the original document. For
19 example, the document file can be modified to resize or re-orient the document with
20 respect to the format in which it originally appeared. Most document scanning apparatus
21 are in the form of a flat-bed scanner. That is, the scanning apparatus includes a
22 transparent (usually glass) platen on which a document can be placed. A cover, which
23 is hingedly attached to the main body of the scanning apparatus, can be closed over a
24 document placed on the platen in order to reduce ambient light intrusion which can
25 adversely affect the quality of the scanned image. Once a document is placed on the
26 platen, the optical scanning device is then moved past the platen in order to scan the
27 document. In another configuration, a document scanning apparatus can include a
28 document sheet feeder which is configured to feed one or more sheets of a document
29 into position for optical scanning. Two common configurations are used. In the first
30 configuration, the optical scanning device remains static while the document is moved
31 past the scanning device. In the other configuration, a transfer device, such as a belt, is
32 used to move the document onto the platen. The scanning device is then moved past
33 the document to thereby scan the document, and the document is then subsequently
34 removed from the platen by the transfer device. A hybrid configuration allows the
35 scanning device to remain static when a sheet feeder is used to transfer the document to

1 the scanning device, but when a document is manually placed on the platen, the
2 scanning devices moves past the document. Although most document scanning
3 apparatus have a platen over which a document can be placed for scanning, in a less
4 common configuration no platen is provided, and the document is moved past a static
5 optical scanning device by a sheet feeder. This latter configuration is commonly found in
6 facsimile machines, which can also function as a scanning apparatus.

7 The advantage of the flat-bed scanning arrangement is that documents (as well
8 as other objects) of various sizes and shapes, which cannot be easily accommodated by
9 a sheet feeder, can be scanned. However, when a document to be scanned exceeds
10 the size of the platen, certain problems result. Turning to Fig. 1, a prior art scanning
11 apparatus 10 is depicted in a plan view. The scanning apparatus 10 is also depicted in a
12 sectional side elevation view in Fig. 2. With reference to Figs. 1 and 2, the prior art
13 scanning apparatus includes a scanner base 30 and a scanner cover 12. The scanner
14 base supports a platen 25 and an optical scanning device 28. The cover 12 is attached
15 to the base 30 by hinges 14, allowing the cover to be moved in direction "Q" (Fig. 2) so
16 that a document can be placed on the platen 25. In the embodiment shown, the cover
17 12 includes a sheet feeder. A sheet of media (such as paper) can be placed in the input
18 tray 16 (Fig. 1). A pick-roller 24 (Fig. 2) can then engage the sheet of media and move it
19 in feed direction "F" (Fig. 1) past the optical scanning device 28 (Fig. 2) using the feed
20 rollers 26. The scanned sheet is then discharged at output area 27. Alternately, a sheet
21 of media can be placed directly on the platen 25 and the optical scanning device 28 can
22 be moved past the sheet using a scanner drive mechanism (not shown). As can be
23 seen in Fig. 1, the sheet feeding section of the cover 12 can induced a fixed upper-edge
24 document guide 18 and a moveable lower edge document guide 22 which is configured
25 to move on track 22 in directions "A". A document sheet having a maximum width "W"
26 can thus be accommodated by the sheet feeder. Typically, the width "W" is the
27 maximum width of the scannable area of the platen 25 (i.e., the area which can be
28 scanned by the scanning device 28). When a document is placed directly on the platen,
29 then the scanning device 28 is limited to scanning an area of length "L" (Fig. 2).

30 Turning to Fig. 3, the prior art scanning apparatus 10 of Figs. 1 and 2 is depicted
31 in a plan view, but with the scanner cover 12 in an open position. Also depicted is an
32 outline of an oversized document "D" which is positioned with the upper left corner "UL"
33 of the document oriented in the upper left corner of the platen 25. The document "D",
34 being of width "WD" and length "LD", is considered "oversized" since at least one of (and
35 in this case, both) the length (LD) and width (WD) of the document "D" exceeds the

1 respective length "L" and width "W" of the scannable area of the platen 25. As is
2 evident, the optical scanning device 28 will not be able to scan the entire document "D"
3 in a single scan.

4 When a sheet feeding device is used, such as is depicted in Figs. 1 and 2, then a
5 document with a document length "LD" greater than the scannable area length "L" can
6 be scanned in a single pass, since the document can be moved past the optical
7 scanning device 28 while the device 28 remains static. However, if the width "WD" of
8 the document "D" exceeds the width "W" of the scannable area of the platen 25, then the
9 sheet feeding device is of no help. Further, if the scanning apparatus 10 is not provided
10 with a sheet feeder (typically at extra cost), then the optical scanner 28 will not be able to
11 scan a document in a single pass where the length "LD" of the document "D" is greater
12 than the length "L" of the scannable area. In the situation depicted in Fig. 3, a user is
13 presented with essentially only one solution if the user desires to scan the entire area of
14 the document "D". That is, the user must manually move the document "D" over the
15 platen 25 a number of times in order to scan the entire area of the document. In the
16 example depicted, the user will need to make a first scan in the position shown. The
17 user will then need to shift the document to the left to encompass the upper right corner
18 "UR" of the document, then shift the document up to encompass the lower right corner
19 "LR" of the document, and then to the right to encompass the lower left corner "LL" (or
20 some combination of these various movements).

21 The above-described movements of the document "D" of Fig. 3 by a user in order
22 to completely scan the area of the document present a number of problems. First of all,
23 the cover 12 presents an impediment to the document and to movement of the
24 document. If the document "D" is of a relatively stiff media (such as cardstock), then the
25 cover 12 can require bending of the document in order to place the document on the
26 platen 25. This can result in damage to the document. While the document can
27 conceivably be rotated to various positions to avoid interference by the scanner cover
28 12, and thus avoid bending the document, this is only feasible when the document
29 length "LD" and the document width "WD" are each shorter than the platen length "L"
30 and width "W". Removing the cover from the scanner base may be of some help in
31 allowing the document to be moved around on the platen. However, this can require a
32 significant amount of work and may result in damage to the scanning apparatus since
33 the covers are typically not intended to be removed by a user. In addition, removing the
34 cover will allow more light to intrude into the scanner during the scanning process,
35 resulting in a low quality final image.

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1 Further, while it is possible to scan the entire document by manually repositioning
2 the document and making a plurality of scans, the result is a plurality of scanned images,
3 rather than a single scanned image. In most instances, the user will desire a single
4 scanned image. Accordingly, in order to acquire a single scanned image of an oversized
5 document, a user will need to assemble a plurality of single scanned images to obtain a
6 single scanned image. This can be done using known image processing software, but
7 the process is difficult to do at best since matching the edges of the various scanned
8 images requires significant image manipulation. Also, in many cases the user is merely
9 guessing where to place the oversized document on the platen to scan the next
10 segment, and the result can be overlapping portions between scanned images, or
11 missing portions which require the user to re-scan the segment.

12 What is needed then is a document scanning apparatus which achieves the
13 benefits to be derived from similar prior art apparatus, but which avoids the
14 shortcomings and detriments individually associated therewith.

15 16 SUMMARY OF THE INVENTION

17 The present invention provides for a document scanning apparatus which is
18 capable of scanning an oversized document. In a first embodiment of the present
19 invention a document scanning apparatus includes a base unit, an optical scanning
20 device located within the base unit, and a cover freely removable from the base unit.
21 The apparatus further includes a document positioning device configured to move a
22 document with respect to the optical scanning device when the document is positioned
23 between the base unit and the cover.

24 A second embodiment of the present invention provides for a document scanning
25 apparatus comprising an optical scanning device, a processor, and a document
26 positioning device configured to position a document with respect to the optical scanning
27 device. The apparatus further includes a document positioning program configured to
28 be executed by the processor and to cause the processor to actuate the document
29 positioning device, and thereby move the document with respect to the optical scanning
30 device.

31 A third embodiment of the present invention provides for a method of optically
32 scanning an oversized document. The method includes placing a first portion of the
33 document over a platen so that a second portion of the document is not placed over the
34 platen. The first portion of the document is then optically scanned by moving an optical
35 scanning device past the first portion of the document. The method includes

1 automatically moving the document in a first direction so that the second portion of the
2 document is placed over the platen. The second portion of the document is then
3 optically scanned by moving the optical scanning device past the second portion of the
4 document.

5 These and other aspects and embodiments of the present invention will now be
6 described in detail with reference to the accompanying drawings, wherein:
7

8 DESCRIPTION OF THE DRAWINGS

9 Fig. 1 depicts a plan view of a prior art document scanning apparatus.

10 Fig. 2 is a side elevation sectional view of the prior art document scanning
11 apparatus depicted in Fig. 1.

12 Fig. 3 depicts another plan view of the prior art document scanning apparatus of
13 Fig. 1.

14 Fig. 4 is a side elevation view depicting a document scanning apparatus in
15 accordance with one embodiment of the present invention.

16 Fig. 5 is a plan view depicting the document scanning apparatus of Fig. 4.

17 Fig. 6 is a side elevation sectional view depicting a document positioning drive
18 device and a scanner cover alignment device which can be used with the present
19 invention.

20 Fig. 7 is a side elevation view depicting another document positioning drive
21 device and scanner cover alignment device which can be used with the present
22 invention.

23 Fig. 8 is a plan view depicting a document scanning apparatus in accordance
24 with a second embodiment of the present invention.

25 Fig. 9 is a side elevation view depicting a document positioning device which can
26 be used with the apparatus depicted in Fig. 8.

27 Fig. 10 is a plan view depicting another document positioning device which can
28 be used with the apparatus depicted in Fig. 8.

29 Fig. 11 is a side elevation view of the document positioning device depicted in
30 Fig. 10.

31 Fig. 12 is a plan view depicting a document scanning apparatus in accordance
32 with a third embodiment of the present invention.

33 Fig. 13 is a side elevation sectional view of the document scanning apparatus
34 depicted in Fig. 12.

1 Fig. 14 is a bottom view of a scanner cover which can be used with the document
2 scanning apparatus depicted in Fig. 12.

3 Figs. 15A and 15B together form a flow chart depicting a series of steps that can
4 be performed to implement the methods of the present invention.

5 Fig. 16 depicts a schematic diagram of components which can be used to
6 implement the methods of the present invention.

7 Fig. 17 is a plan view depicting a document scanning apparatus in accordance
8 with a fourth embodiment of the present invention.

9 Fig. 18 is side view depicting another document positioning device which can be
10 used with the apparatus depicted in Fig. 8.

11 12 DETAILED DESCRIPTION OF THE INVENTION

13 The present invention provides methods and apparatus which allow an oversized
14 document to be entirely scanned without requiring a user to manually set the document
15 on a document scanning apparatus a plurality of times and performing a plurality of
16 optical scans of different portions of the document.

17 In the following discussion, when I say "document scanning apparatus" I mean
18 an apparatus having an optical scanning device capable of optically scanning a
19 document, or a portion thereof, to generate an electronic representation of the scanned
20 document or document portion. By a "document" I mean a sheet of media which
21 contains an image, such as text or a graphical image. For example, a document can be
22 a sheet of paper. By the expression "oversized document" I mean a document in which
23 at least one of the length and/or width of the document exceeds the respective length
24 and/or width of the scannable area of the document scanning apparatus. By "scannable
25 area" I mean an area defined on the scanning apparatus, and which can be scanned by
26 the optical scanning device. An example of an oversized document is a poster
27 measuring 2' by 3' (approx. 0.7 m by 1 m).

28 Generally, a document scanning apparatus in accordance with the present
29 invention includes a base unit and a cover which is freely removable from the base unit.
30 By "freely removable" I mean that the cover is not directly attached to the base unit, such
31 as by hinges (see for example the prior art see hinges 14, Fig. 1). Preferably, the cover
32 is configured to be lifted free of the base unit without requiring the use of tools or the like
33 to detach the cover from the base unit. Although the cover of the present invention can
34 be tethered to the base of the scanning apparatus by a cord or wire, this would still be
35 considered "freely removable". More preferably, the removability of the cover allows a

1 document to be placed over the base unit such that the edges of the document can
2 overhang the base unit on any or all sides of the base unit. Accordingly, an oversized
3 document can be placed on the base unit of the document scanning apparatus, and then
4 the cover placed over the document so as to secure the document between the cover
5 and the base unit. The document scanning unit includes an optical scanning device
6 which can be located in the base unit, and a document positioning device configured to
7 move the document with respect to the base unit and/or the optical scanning device.
8 Preferably, the document scanning apparatus further includes an alignment device
9 configured to maintain the cover in generally fixed spatial alignment with respect to the
10 base unit when the document positioning device is moving a document. I will now
11 describe specific examples of methods apparatus in accordance with the present
12 invention.

13 Turning to Fig. 4, a document scanning apparatus 100 in accordance with the
14 present invention is depicted in a side elevation view. The document scanning
15 apparatus 100 includes a base unit 120 and a cover 110. As can be seen, in this
16 example there is no physical connection between the base unit 120 and the cover 110,
17 and the cover is merely resting on top of the base unit. For illustrative purposes, a
18 document "D" is depicted as being positioned between the base unit 120 and the cover
19 110. The document scanning apparatus 100 further includes an optical scanning device
20 128 which is configured to optically scan a document. Preferably, the optical scanning
21 device 128 is configured to move in a direction from left to right (and visa versa) to scan
22 the document, and in this case the base unit 120 includes a platen (shown in Fig. 5 as
23 132, and described below). The document scanning apparatus 100 includes a
24 document positioning device, which is depicted here as powered roller 122 which
25 protrudes slightly above the base unit 120 such that a sheet of media (document "D")
26 which is laid over the base unit contacts the powered roller 122. The powered roller
27 preferably has a tactile surface so that it can engage the document "D" and move the
28 document in direction "X" (or opposite-X) by rotation of the roller 122 in respective
29 directions "R" or "R' ". A complementary idler roller 112, which is located in the cover
30 110, rests against the powered roller 122, with the document "D" trapped between the
31 rollers 122 and 112. The base unit 120 can further include a second roller 124, which is
32 preferably (but not necessarily) a powered roller and which also protrudes slightly above
33 the base unit 120, as does roller 122. A second idler roller 114, located in the cover 110,
34 rests against the roller 124, with the document "D" trapped between the rollers 124 and

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1 114 when the cover 110 is placed on the base unit 120. In this way, the cover 110 is
2 supported only by the rollers 122 and 124, which are located in the base unit 120.

3 As can be seen, the configuration depicted in Fig. 4 is unstable in that the cover
4 110 will tend to move off of the rollers 122 and 124 once the powered roller 122 is
5 engaged. Accordingly, the document scanning apparatus preferably includes an
6 alignment device configured to maintain the position of the cover 110 relative to the base
7 120 as the document is moved about by the document positioning device 122. In the
8 example depicted, the alignment device consists of a first magnet 126 which is located in
9 the base unit 120, and a complementary second magnet 116 which is located in the
10 cover 110 and which is proximate the first magnet 126 when the cover is positioned over
11 the base unit 120. As can be seen by a plan view of the document scanning apparatus
12 100 (Fig. 5), in this example there are two magnets 126 located in the base unit 120.
13 The magnetic attraction between the magnets 116 and 126 (Fig. 4) tends to maintain the
14 cover in a constant position with respect to the base unit 120, but also allows the
15 document "D" to completely isolate the base unit 120 from the cover 110. In this way the
16 document "D" can be freely moved around over the base unit 120 without interference
17 from the cover 110.

18 In the plan view of Fig. 5, the cover 110 of the document scanning apparatus 100
19 of Fig. 4 has been removed so that only the base unit 120 can be seen. The base unit
20 includes a transparent platen 132 over which a document can be placed, and then the
21 cover can be placed over the document (as in Fig. 4). The document positioning device
22 (powered roller 122) can then be actuated to move the document with respect to the
23 platen 132 and the optical scanning device. In the example depicted in Fig. 5, an
24 oversized document "D" (indicated in outline) is placed over the base unit 120.
25 Preferably, the document "D" is initially placed with the top edge "TE" and the left side
26 "LS" positioned in the upper left corner "UL" of the platen 132. The powered roller can
27 then move the document "D" in the direction "X" until the right side "RS" of the document
28 "D" is aligned with the right side of the platen 132. (A more complete description
29 of the operation of the document scanning apparatus 100 will be provided further below.)
30 It is evident that the configuration of the document scanning apparatus 100 depicted in
31 Fig. 5 will not be able to automatically move the document "D" in direction "Y" so that the
32 bottom edge "BE" of the document can be scanned, since the drive roller 122 can only
33 move the document "D" in the X-direction, and in the opposite ("negative-X") direction.
34 Consequently, a user will need to manually lift the document "D" from the base unit 120
35 and reposition it over the platen 132 in order to scan the area of the document between

1 the bottom edge "BE" and the lower edge of the platen (defined by width "W"). However,
2 in additional embodiments of the present invention, the document scanning apparatus
3 can be configured to move the document "D" in both the "X" direction and the "Y"
4 direction. Those embodiments will be described further below.

5 Turning to Fig. 6, an alternate configuration for an alignment device which can be
6 used in a document scanning apparatus in accordance with the present invention is
7 depicted. Fig. 6 shows a partial side elevation sectional view of a document scanning
8 apparatus 200, having a base unit 220 similar to the base unit 120 of the document
9 scanning apparatus 100 of Fig. 4. The base unit 220 includes a document positioning
10 device 222, which is similar to the powered roller 122 of Fig. 4. However, the cover 210
11 of the document scanning apparatus 200 differs from the cover 110 of the apparatus 100
12 of Fig. 4 in that the alignment device in the cover 210 comprises an arcuate bearing
13 surface 212 formed in the cover 210. The arcuate bearing surface 212 forms a pocket
14 configured to receive at least a portion of the powered roller 222 therein when the cover
15 210 is aligned on the base unit 220. Preferably, the arcuate bearing surface 212 is
16 covered with a low-friction coating (such as tetrafluoroethylene, or "TFE") to allow a
17 document "D" to slide more easily over the surface 212.

18 Yet another alternative configuration for an alignment device which can be used
19 in a document scanning apparatus in accordance with the present invention is depicted
20 in Fig. 7. Fig. 7 shows a powered roller 222 (the same as roller 222 of Fig. 6) which is
21 located in a base unit (not shown). A cover 210A includes an arcuate surface 212A.
22 Located within the cover 210A, and positioned such that they will be disposed between
23 the arcuate surface 212A and the roller 222 when the cover 210A is placed over the
24 base unit, are a plurality of parallel, spaced apart cylindrical bearings 215 configured to
25 contact the powered roller 222 when the cover 210A is aligned on the base unit (not
26 shown). Preferably, the cylindrical bearings are supported in the cover 210A such that
27 they are free to rotate about a central axis, and thus roll as a document (not shown) is
28 moved between the powered roller 222 and the cylindrical bearings 215. Although the
29 cover 210A of Fig. 7 is depicted as having 6 cylindrical bearings, in fact only two are
30 needed to straddle the powered roller 222 and thus align the cover 210A with respect to
31 the base unit.

32 Although the rollers 122 and 124 in fig. 5 are depicted as spanning the entire
33 width of the platen 132, in fact each roller can be replaced with two or more shorter,
34 spaced-apart rollers. As will be seen in the embodiment of the invention described
35 immediately below, the rollers can be shaped such that the area of contact between the

1 document and the roller is very small. Such will allow greater pressure to be applied by
2 the roller to the document (since the weight of the cover will be distributed over a much
3 smaller area on the document), facilitating movement of the document by the roller.

4 Turning now to Fig. 8, a second embodiment of a document scanning apparatus
5 300 in accordance with the present invention is depicted in plan view. For the sake of
6 simplification, the cover is not shown, although the cover can be similar to the cover 110
7 of Fig. 4, except as modified per the following description. The document scanning
8 apparatus 300 of Fig. 8 includes a base unit 320 which includes a platen 340 and an
9 optical scanning device 328. The alignment device here includes four magnets (332,
10 334, 336 and 338) positioned adjacent the four corners of the base unit 320. In this
11 instance, the cover (not shown) will have four complementary magnets positioned
12 adjacent the corners of the cover so that they align with the four magnets in the base
13 unit 320 when the cover is placed over the base.

14 The primary difference between the document scanning apparatus 300 of Fig. 8
15 and the apparatus 100 of Fig. 4 is the document positioning device. While the apparatus
16 100 only had a powered roller 122 which allowed movement of a document only in
17 direction "X" (and the opposite direction, "negative-X", as described above with respect
18 to Fig. 5), the document scanning apparatus 300 of Fig. 8 uses at least a first driven ball
19 322 located adjacent a first one of the four corners of the base 310. The driven ball is
20 configured to be selectively rotatable about a first axis in direction "R1" to thus move a
21 document in the "X"/negative-X directions, as well as about a second axis in direction
22 "R2" to thus move a document in the "Y" and negative-Y directions. The base can
23 further include a second driven ball located adjacent a second one of the four corners of
24 the base, such as ball 326, 324 or 342. Preferably, the base unit 320 includes four balls
25 322, 324, 326 and 342, at least one of which is driven, while the other balls are idler
26 balls. In a preferred embodiment, all four balls 322, 324, 326 and 342 are driven, thus
27 allowing improved control of the document positioning by the document positioning
28 device, since the document will not be able to rotate about an idler ball while being
29 positioned by a driven ball. Further, selected ones of the balls can be configured to drive
30 the document in one direction, while other of the balls are configured to move the
31 document in a second direction which is typically (but not necessarily) orthogonal to the
32 first direction.

33 When balls 322, 324, 326 and 342 are used to support the cover (not shown)
34 over the base 320 (similar to the depiction in Fig. 4), then the alignment device can be
35 similar to the alignment devices depicted in Figs. 6 and 7. For example, with respect to

Fig. 6, if the arcuate surface 212 is cup-shaped to receive one of the balls 322, 324, 326 and 342, then the document "D" can be placed between the ball and the arcuate surface. With respect to Fig. 7, the cylindrical bearings 315 can be replaced with a series of ball bearings placed within a race and which face inwardly to contact the upper surface of one of the balls 322, 324, 326 and 342 (Fig. 8). Alternately, the cover can have complementary idler balls configured to match with balls 322, 324, 326 and 342 in the base unit 320. Such a configuration is similar to the side view of the document scanning apparatus 100 of Fig. 4, except that the rollers 112, 114, 122 and 124 are replaced with balls. Such a configuration increases the pressure applied to the document by the document positioning device, which can improve the traction force applied by the driven ball to the document. Further, the alignment device can comprise a first set of magnets 332, 334, 336 and 338 located in the base unit 320, and which are configured to interact with a second set of magnets in the cover.

Figs. 9 through 11 depict two different methods by which one (or more) of the balls 322, 324, 326 and 342 can be driven to thus act as a document positioning device. With respect to Fig. 9, the driven ball system 322 of Fig. 8 is depicted in a side elevation sectional view (although cross section lines have been eliminated to simplify the drawing and facilitate understanding). The driven ball system 322 includes a ball 3220 having a tactile outer coating 3222 which can facilitate engagement of a document by the ball. Set within the ball 3220 are a plurality of fixed permanent magnets 3224. The ball is positioned within a cradle 3226. Positioned around the outside of the cradle are a plurality of electromagnets 3228. The electromagnets 3228 are connected to a switching circuit 350 which selectively actuates the electromagnets 3229 to cause them to repel or attract the permanent magnets 3224 set within the ball 3220. The switching performed by the switching circuit 350 can be performed by a processor/controller 352. In this way the ball 3220 can be made to rotate in either direction (R or R') about axis "A1" and thus act as the document positioning device to move a document in the "X" or negative-X direction (Fig. 8). The cradle can also have another set of electromagnets (not shown) positioned orthogonal to the first set of electromagnets 3228 to allow the ball 3220 to be rotated about axis "A2". In this way a single driven ball 3220 can be used to position a document in both the "X" and "Y" directions (Figs. 5 and 8).

Fig. 10 depicts a plan view of a different driven-ball document positioning device 322'. Fig. 11 depicts a side elevation view of the document positioning device 322' depicted in Fig. 10. With respect to Figs. 10 and 11, the document positioning device 322' includes a ball 3250 which can have a tactile outer coating to facilitate engagement

1 of a document by the ball 3250. The ball is set within a cup 3254 (Fig. 11) which is
2 supported on a frame 3270. The ball can freely rotate within the cup 3264. Two power-
3 driven capstans 3252 (each driven by a drive motor 3254) contact the ball 3250 above
4 the equator of the ball. The driven capstans 3252 can drive the ball 3250 in directions R
5 and R' to thus move a document placed on top of the ball in respective directions "X"
6 and negative-X (Figs. 5 and 8). The driven capstans 3252 and drive motors 3254 can
7 be mounted on support members 3260, which in turn are connected to the frame 3270.
8 The frame 3270 is supported on a frame positioner 3272 (such as a solenoid) which
9 allows the frame 3270 to be rotated in direction "P1" (as well as in the opposite
10 direction). Thus, by using the frame positioner 3272 to rotate the frame 3270 by ninety
11 degrees, the positioning direction of the ball 3250 can be rotated so that the ball can
12 move a document in the "Y" direction (Figs. 5 and 8). Accordingly, the document
13 positioning device 322' of Figs. 10 and 11 can be used to position a document in both
14 the "X" and "Y" directions with respect to a platen (340, Fig. 8) or an optical scanning
15 device (328, Fig. 8). When the frame positioner 3272 is actuated to rotate the frame
16 3270, the ball 3250 will pivot about a document in contact with the top of the ball (as
17 viewed in Fig. 11). Generally, this will not cause significant friction between the ball
18 3250 and the document, resulting in movement of the document when the frame 3270 is
19 rotated. However, in the event that the document is found to experience significant
20 movement during rotation of the frame 3270, then the frame (and consequently the ball
21 3250) can be mounted on a retractable base (not shown) allowing the ball 3250 and
22 frame 3270 to be moved downward (as viewed in Fig. 11) so that the ball does not
23 contact the document during the rotation of the frame 3270.

24 A third type of driven ball assembly which can be used in the base unit 320A of a
25 document scanning apparatus in accordance with the present invention is depicted in
26 Fig. 18 in side elevation view. The drive ball assembly includes a ball 376 which rests in
27 a curved pocket in the bottom panel 374 of the base unit 320A. In the example shown, a
28 plurality of ball bearings 378 are disposed between the curved pocket and the ball 376 to
29 reduce friction between the ball 376 and the bottom panel 374. The ball 376 protrudes
30 slightly above the top panel 370 of the base unit 320A. A removable panel 372 can be
31 moved in direction "T" so that the ball 376 can be removed for cleaning or replacement.
32 A first drive motor 382, which is supported on the bottom panel 374, drives a first
33 capstan 380 which is in contact with the ball 376. The capstan 380 can be used to drive
34 the ball 376 in directions R and R' about axis "Z" (which projects into the sheet on which
35 the figure is drawn). A second capstan 384, which is in contact with the ball 376A, is

1 driven by a second drive motor 386 (via shaft 390). The capstan 384 can be used to
2 drive the ball 376 in "up" and "down" directions about axis "W". Thus, the capstans 380
3 and 384 can be used to drive the ball in "X" and "Y" directions (Fig. 8), and thus position
4 an oversized document placed over the base unit 320A (Fig. 18). The capstans 380 and
5 384 can also be configured to selectively individually retract away from the ball 374 to
6 reduce friction when the non-retracted capstan is driving the ball. This can be
7 accomplished, for example, by mounting the motors 382 and 386 on pivoting frames and
8 then using an actuator, such as a solenoid, to pivot the frame.

9 A variation on the document scanning apparatus 300 of Fig. 8, and 100 of Fig. 4,
10 is depicted in a plan view in Fig. 12. The document scanning apparatus 400 of Fig. 12
11 includes a base unit 420 and a cover (not shown) which can be similar to the cover 110
12 of the document scanning apparatus 100 of Fig. 4. The base unit 420 of the document
13 scanning apparatus includes a main body 430 which supports an optical scanning
14 device 428. The base unit 420 further includes a plurality of rollers 422, 424, 442 and
15 444, which are similar to rollers 122 and 124 of Fig. 4, except that rollers 442 and 444
16 are mounted orthogonal to rollers 422 and 424. Specifically, at least one of the first set
17 of rollers 422 or 424 can be a power driven roller configured to act as a document
18 positioning device to selectively move a document "D" in the "X" and negative-X
19 directions, in the manner described above with respect to roller 122 of Fig. 4. Likewise,
20 at least one of the second set of rollers 442 or 444 can be a power driven roller
21 configured to act as a document positioning device to selectively move a document "D"
22 in the "Y" and negative-Y directions. Preferably, all of the rollers 422, 424, 442 and 444
23 are powered rollers. In this manner, the document can always be pulled into position,
24 rather than being pushed into position. "Pushing" the document into position may result
25 in the document binding between the cover and the platen. For example, if only roller
26 424 were configured to move the document in the "X" direction (and the negative-X
27 direction) and roller 422 were an idler roller, then roller 424 would be required to "push"
28 the document "D" in the "X" direction.

29 As is apparent, if all four rollers 422, 424, 442 and 444 are positioned to
30 simultaneously contact a document placed over the base unit 420, then movement of the
31 document across the base unit can be inhibited by rollers oriented orthogonally to the
32 direction of movement. For example, while the document "D" is moved in the "X"
33 direction, then it will scuff across rollers 442 and 444. Accordingly, the document
34 scanning apparatus 400 preferably is configured to disengage rollers from contacting a
35 document when the document is to be moved in a direction in which the rollers can

1 inhibit free movement of the document. One configuration for accomplishing this is
2 shown in Fig. 13, which depicts a side elevation sectional view of the document
3 scanning apparatus 400 of Fig. 12. In this configuration the rollers 422 and 424 are
4 selectively retractable to respective positions 422' and 424' to thereby move the rollers
5 out of contact with a document placed over the platen 432. This can be accomplished
6 by supporting each roller 422 and 424 on support arms 462, which are extensibly
7 connected to actuators 460. Actuators 460 can be, for example, solenoids supported by
8 the base unit body 430. Rollers 442 and 444 (Fig. 12) can be similarly configured so
9 that they can be retracted out of contact with a document placed over the platen 432.
10 Thus, with respect to Fig. 12, when the document "D" is to be moved in the "X" direction
11 by rollers 422 and/or 424, these rollers are extended to contact the document, while
12 rollers 442 and 444 are retracted so as to not contact the document. Similarly, when the
13 document "D" is to be moved in the "Y" direction by rollers 442 and/or 444, these rollers
14 are extended to contact the document, while rollers 422 and 424 are retracted.

15 Turning now to Fig. 16, a schematic diagram depicts an embodiment of an
16 exemplary system 600 which can be used to automate the document scanning
17 apparatus 100 (Fig. 4), 300 (Fig. 8) and 400 (Fig. 12). The system 600 includes a
18 processor or controller 610 which coordinates the operation of the other components,
19 and also can be used to manage data transfer functions, as will be described below.
20 The system 600 further includes a memory device 620 which can be accessed by the
21 processor 610. The memory device can be, for example, a semiconductor memory
22 device or a disk-type memory device (such as a magnetic disk). The memory device
23 620 can have a random access memory component 622 which allows the processor 610
24 to temporarily store data in the memory device. The memory device 620 preferably
25 includes an "Oversized Document Positioning/Scanning Program" (or "Oversized
26 Document Program"), which comprises a series of executable instructions which can be
27 executed by the processor 610 to allow the processor to cause various components of
28 the system 600 to function.

29 The document scanning apparatus system 600 can further include a user
30 interface 670 which can allow a user to enable, disable or modify the Oversized
31 Document Program. For example, a user can access the user interface 670 to indicate
32 that a document is oversized in only one direction, and in which direction ("X" or "Y") the
33 document is oversized. The user interface can also be used to provide information to a
34 user, such as instructions to place a document on the base unit of the scanning
35 apparatus, or that the scanning process has been completed.

1 The various operational components of the document scanning apparatus system
2 600 have generally been described above. These operational components include an
3 optical scanning device (128, Fig. 4) which can be moved across a platen (132, Fig. 5)
4 by a scanning device motor 635 (Fig. 16). The scanning device motor 635 can be
5 actuated by the processor 610, and signals generated by the scanning device 428 can
6 be transmitted to the memory device 620 via the processor 610. As shown, the
7 scanning system 600 further includes an "X" direction document positioning drive device
8 650 (e.g., driven balls (322, 324, 326 and/or 342, Fig. 8), or rollers (422 and/or 424, Fig.
9 12)), and a "Y" direction document positioning drive device 660 (e.g., driven balls (322,
10 324, 326 and/or 342, Fig. 8), or rollers (442 and/or 444, Fig. 12)). The document
11 positioning devices 650 and 660 can be actuated by the processor 610.

12 The document scanning system 600 can further include a document edge
13 detector 640. The operation of the document edge detector 640 will be more fully
14 described below, but generally its function is to transmit a signal to the processor 610 in
15 response to detecting one of the presence or absence of an edge of a document
16 proximate at least one edge of the platen, such as platen 432, Fig. 12. In this way the
17 processor 610 can ascertain whether a document placed over the platen should be
18 moved or not, and thus whether or not to actuate the document positioning devices 650,
19 660.

20 One example of a document edge detector is shown in Fig. 12, wherein four
21 sensors 450 are positioned adjacent each of the four corners of the platen 432. In the
22 following example, the sensors are provided with a light source (such as an LED), and a
23 light detector configured to detect reflected light and generate a signal in response
24 thereto. Turning to Fig. 14, a document scanning apparatus cover 710 of the present
25 invention is shown in a bottom view. That is, the area depicted in the figure will be the
26 side of the cover placed over the base unit of the document scanning apparatus. The
27 cover 710 can be used, for example, with the document scanning apparatus base 720 of
28 Fig. 12. The cover 710 includes a bright reflective surface 405 (preferably white)
29 attached to a support platform 413. The cover can further include alignment devices
30 (not shown) which can take any of the forms described above to maintain alignment
31 between the cover 710 and the base unit 720 (Fig. 12) when the cover is placed over the
32 base unit.

33 The reflective surface 405 of the cover 710 is configured to cover the platen 432
34 (Fig. 12) of the base unit when the cover is placed over the base unit. In this example,
35 the scannable area of the platen 432 is less than the entire area of the platen, and

1 specifically includes only the area 411 defined on the reflective surface 405 (Fig. 14),
2 while the perimeter areas 407 of the reflective surface 405 are not within the scannable
3 area. Nonetheless, the perimeter areas 407 will still lie over the platen 432 (Fig. 12),
4 and thus light from the edge detector sensors 450 will be able to contact the reflective
5 surface 405 (Fig. 14) in the perimeter areas. As can be seen, the four corners 415 of the
6 reflective surface 405 are blacked-out so that they are non-reflective. These dark areas
7 415 will align with the sensors 450 (Fig. 12) when the cover 710 is placed over the base
8 unit 420. Accordingly, light from the edge detector sensors 450 will not be reflected from
9 these dark areas 415 when only the platen lies between the dark areas 415 and the
10 sensors 450. However, light will be reflected from a document that is placed between
11 the sensors 450 and the dark areas 415. In this way, the sensors 450 will be able to
12 detect when a portion of a document lies beyond the scannable area 411. Once the
13 edge of a document is moved from the perimeter area 407 onto the scanable area 411,
14 then the dark areas 415 nearest that edge of the document will be exposed.
15 Consequently, the respective sensors 450 will indicated that no further movement of the
16 document is required to place the document over the scannable area (unless an
17 orthogonal edge of the document is determined to still lie beyond the scannable area).

18 A further embodiment of a document scanning apparatus 700 in accordance with
19 the present invention is depicted in a plan view in Fig. 17. As can be seen, the
20 document scanning apparatus 700 is similar to the document scanning apparatus 300 of
21 Fig. 8. The document scanning apparatus 700 includes a cover, which is not shown for
22 the sake of simplicity, but can be similar to covers 110 (Fig. 4) and 410 (Fig. 14). the
23 document scanning apparatus 700 also includes a base unit 720 which includes a platen
24 740 and an optical scanning device 728. The alignment device used in the example
25 depicted in Fig. 17 comprises four magnets 722 which are positioned in the four corners
26 of the base unit 720 near the upper surface 702 of the base unit. The magnets are
27 configured to align with complementary magnets in the cover (not shown) in the manner
28 described above with respect to magnets 116 and 126 in Fig. 4. The document
29 positioning device used in the apparatus 700 includes four driven balls 724A-D, each
30 ball located proximate a corner of the upper surface 702 of the base unit 720. The
31 driven balls can operate, for example, like the driven balls depicted in Figs. 9, 10, 11 and
32 18, described above.

33 The document scanning apparatus 700 of fig. 17 further includes eight edge
34 detectors which can operate similar to the edge detectors 450, described above with
35 respect to Figs. 12 and 14. In the embodiment depicted in Fig. 17, the edge detectors

1 are positioned at the upper surface 702 of the base unit 720, rather than being placed
2 below the platen, as in Fig. 12. In the apparatus 700, two spaced-apart edge detectors
3 730 and 732 are positioned adjacent the left edge of the base unit 720, two spaced-apart
4 edge detectors 726 are positioned near the top edge of the base unit, two spaced-apart
5 edge detectors 736 and 734 are positioned near the right edge of the base unit, and two
6 spaced-apart edge detectors 744 and 738 are positioned near the bottom edge of the
7 base unit. As can be seen, the edge detectors are arranged such that each corner of
8 the upper surface 702 of the base unit 720 includes two edge detectors oriented at
9 ninety degrees with respect to one another. For example, the upper left corner of the
10 base unit 720 includes edge detectors 730 and 726. At each corner of the base unit
11 720, a driven ball 726 is located inward of the edge detectors at the corner, and outward
12 of the respective corner of the platen 740. The edge detectors depicted in Fig. 17 can
13 be the document edge detecting sensors 630 of Fig. 16, which are connected to
14 processor 610.

15 The configuration of the document scanning apparatus 700 depicted in Fig. 17 is
16 particularly useful for aligning an oversized document with respect to a platen (and thus,
17 the scannable area of the platen) prior to (or during) the process of moving the
18 document about the scanable area for scanning in accordance with the present
19 invention. For example, an oversized document "D" is depicted as being placed over the
20 base unit 720. As can be seen, the edges of the document are misaligned with the
21 edges of the platen. That is, the left edge of the document "D" is not parallel with the left
22 edge of the platen 740. Although the misalignment is exaggerated for purposes of
23 illustration, this type of misalignment can occur when a user initially places the document
24 "D" over the platen 740. Misalignment can also occur during the process of moving the
25 document over the scannable area.

26 In the example shown in Fig. 17, the document "D" can be aligned over the base
27 unit 720 using the edge detectors 726, 730, 732, 744, 738, 736 and 734, in conjunction
28 with a processor (610, Fig. 16) and an Oversized Document Positioning Program (624)
29 as follows. Edge detectors 726 and 744 detect the document "D", while edge
30 detector 738 does not detect the document. Likewise, edge detectors 730, 736 and 734
31 detect the document "D", while edge detector 732 does not detect the document.
32 Provided with this information, the processor 610 (Fig. 16), using the Document
33 Positioning Program 624, is able to determine that the document "D" is misaligned with
34 respect to the platen 740, and that the document should be rotated clockwise in direction
35 "Q" in order to properly align the document. The processor 610 then actuates the driven

balls 724A and 724C to move the left edge of the document "D" in the "Y" direction, while driven balls 724B and 724D are actuated to move the document "D" in the opposite-Y direction. This causes the document "D" to rotate in direction "Q".

The rotation of the document "D" continues until the two edge detectors on each edge of the base unit are either both covered by the document, or both not-covered by the document. Once this condition occurs, proper alignment of the document with respect to the base unit is indicated. To verify this alignment, the document can be moved with in a single direction (for example, direction "X" or "Y") to uncover edge detectors along one side which were previously both covered. If both of the previously-covered edge detectors are uncovered at the same time (which the edge detectors will be able to detect), then the document is correctly aligned. However, if the previously-covered edge detectors are not both uncovered at the same time, then additional alignment of the document can be performed in the manner described above.

I will now describe one example of how a document scanning apparatus in accordance with the present invention can be operated to automatically scan the entire area of an oversized document. Figs. 15A and 15B together depict a flowchart 500 of steps which can be implemented as computer executable steps, and thus comprise the Oversize Document Scanning Program 624 of Fig. 16. It is understood that the example depicted in Figs. 15A and 15B is exemplary only, and that different steps can be used, or the steps performed in a different sequence, to operate the apparatus of the present invention in accordance with the methods of the present invention. In the following discussion, we will assume that the steps of the flowchart 500 are executed by a processor (such as processor 610, Fig. 16), which is used in conjunction with a document scanning apparatus of the present invention, such as apparatus 400 of Fig. 12.

The general process described by the flowchart 500 is that an oversized document is placed over the scannable area of a platen of a document scanning apparatus. The document is incrementally moved over the scannable area by a document positioning device. The increments of movement are the length or width of the scannable area. Between incremental moves, the portion of the document which is positioned over the scannable area is optically scanned. Preferably, the document is initially moved left-to-right until the entire length of the document is scanned; if the width of the document exceeds the width of the scannable area, then the document is moved up by the width of the scannable area. Thereafter the document is incrementally moved right-to-left. This sequence is continued until the entire document has been scanned.

1 The result is a series of scanned document segments which can later be compiled into
2 an overall scanned image.

3 Turning now to Fig. 15A, at step 502 the Oversized Document Scanning Program
4 is enabled, as for example by the user interface 670 of Fig. 16. The document is
5 positioned on the platen (or "scanning bed") to align one corner of the document in the
6 upper left corner of the scannable area of the platen. This step can be performed
7 manually by the user. At step 504 the portion of the document on the platen (i.e., the
8 portion within the scannable area of the platen) is optically scanned using an optical
9 scanning device (such as 428 of Fig. 12). The scanned document segment is then
10 stored in computer readable memory (such as RAM 622, Fig. 16). At step 506 the
11 processor then checks to determine whether the right edge of the document exceeds the
12 right edge of the scannable area. For example, with respect to Fig. 12, the right side
13 "RS" of the document "D" exceeds the right edge of the scannable area (on the platen
14 432). This determination can be accomplished using the edge detector sensors 450 and
15 the cover 710 (Fig. 14), described above. However, if the right side of the document is
16 within the scannable area, then at step 510 a determination is made whether the bottom
17 edge of the document (e.g., bottom edge "BE" of document "D" in Fig. 12) exceeds the
18 bottom edge of the scannable area. If the bottom edge of the document does not
19 exceed the bottom edge of the scannable area, then at step 512 the document
20 segments (in this case, only one) are compiled and the scanning process is terminated.
21 That is, if it is determined at steps 506 and 510 that both the right edge and the bottom
22 edge (i.e., the lower right corner) of the document are within the scannable area, then
23 this indicates that the document has been completely scanned, since at step 502 the
24 document was initially placed with its upper left corner in the upper left corner of the
25 scannable area.

26 However, if at step 506 it is determined that the right edge of the document
27 exceeds the right edge of the scannable area, then at step 508 the document positioning
28 device which is used to move the document in the "X" direction (see Fig. 12) is engaged,
29 and the document is moved to the left by the length of the scannable area. Thereafter
30 the program returns to step 504 and the portion of the document placed over the
31 scannable area is scanned. As can be seen, this sequence of moving the document to
32 the left and scanning it is continued until the right edge of the document no longer
33 exceeds the right edge of the scannable area (as determined at step 506). Once the right
34 edge of the document is brought within the scannable area and scanned (step 504), then
35 at step 510 (described above) the determination is made whether the bottom edge of the

1 document exceeds the bottom edge of the scannable area. If so, at step 514 the
2 document positioning device which is used to move the document in the "Y" direction
3 (see Fig. 12) is engaged, and the document is moved "up" by the width of the scannable
4 area. The portion of the document positioned over the scannable area is then scanned
5 at step 516. At step 518 (Fig. 15B) a determination is made whether the left edge of the
6 document (e.g., "LE" of document "D", Fig. 12) exceeds the left edge of the scannable
7 area. If not, then a check is again made at step 524 to determine whether the bottom
8 edge of the document exceeds the bottom edge of the scannable area. If not, then at
9 step 526 the scanned document segments are compiled and the scanning process is
10 terminated.

11 If at step 518 it is determined that the left edge of the document exceeds the left
12 edge of the scannable area, then at step 520 the document positioning device which is
13 used to move the document in the opposite direction of "X" (see Fig. 12) is engaged, and
14 the document is moved to the right by the length of the scannable area. At step 520 the
15 portion of the document positioned over the scannable area is then scanned, and the
16 process (steps 518 and 520) is repeated until the left edge of the document lies within
17 the scannable area. At this point the process moves to step 524 to determine if the
18 bottom edge of the document exceeds the bottom edge of the scannable area (as
19 described above). If the bottom edge of the document exceeds the bottom edge of the
20 scannable area, then at step 528 the document positioning device which is used to move
21 the document in the direction "Y" (see Fig. 12) is engaged, and the document is moved
22 up by the width of the scannable area. The program then returns to step 504. As is
23 evident, the process of shifting the document to the left, up, to the right, up and back to
24 the left is continued until the entire document has been scanned. Thereafter, all of the
25 scanned document segments can be compiled by the process to provide a single
26 scanned image of the document.

27 A further embodiment of the present invention provides for a method of optically
28 scanning an oversized document. The method includes placing a first portion of the
29 document (such as document "D" of Fig. 12) over a platen (such as 432, Fig. 12) so that
30 a second portion of the document is not placed over the platen. (For example, the
31 second portion of the document can be the portion of the document "D" which is to the
32 right of the portion of the document placed on platen 432 in Fig. 12.) The first portion of
33 the document is then optically scanned by moving an optical scanning device (as 428,
34 Fig. 12) past the first portion of the document. The document is then automatically
35 moved in a first direction so that the second portion of the document is placed over the

1 platen. This can be accomplished, for example, by using the document positioning
2 devices 422, 424, 442, and/or 444 of Fig. 12, as controlled by the exemplary Document
3 Positioning Program 500 (Figs. 15A and 15B), and 624 (Fig. 16). The second portion of
4 the document is then optically scanned by moving the optical scanning device past the
5 second portion of the document. Further, when the document is placed over the platen
6 and a third portion of the document is not placed over the platen (such as the portion of
7 the document "D" which is below the platen 432 in Fig. 12), the method can further
8 include automatically moving the document in a second direction which is orthogonal to
9 the first direction. (For example, the document "D" of Fig. 12 can be moved in the "Y"
10 direction, which is orthogonal to the "X" direction.) Thus, the third portion of the
11 document will be placed over the platen. Thereafter, the third portion of the document
12 can be optically scanned by moving the optical scanning device (e.g., 428, Fig. 12) past
13 the third portion of the document.

14 Further, when the document is defined by a first edge (as edge "RS" in Fig. 12)
15 which is not placed over the platen when the first portion of the document is placed over
16 the platen, the method can further include automatically and sequentially moving the
17 document a plurality of times in the first direction over the platen until the first edge of the
18 document is placed over the platen. The document is optically scanned each time the
19 document is sequentially moved over the platen in the first direction. This can
20 correspond to the sequential steps 506, 508 and 504 of the flowchart 500 of Fig. 15A.
21 Likewise, the document can be defined by a second edge (as bottom edge "BE" of
22 document "D" of Fig. 12) which is orthogonal to the first edge (as edge "RS") and which
23 is not placed over the platen when the first portion of the document is placed over the
24 platen. In this instance, the method can further include automatically and sequentially
25 moving the document a plurality of times in a second direction (e.g., direction "Y", Fig.
26 12) over the platen until the second edge of the document is placed over the platen. The
27 document is optically scanned each time the document is sequentially moved over the
28 platen in the second direction. This can correspond to the sequential steps 510, 514
29 and 516 of the flowchart 500 of Fig. 15A.

30 To paraphrase the above description of the method of the present invention, an
31 oversized document is automatically and sequentially moved over a scannable area in
32 one direction (or two orthogonal directions), and optically scanned between sequential
33 moves, so that ultimately the entire document is scanned by an optical scanning device.

34 The method of the present invention can further include scanning the first and
35 second portions of the document to generate respective first and second scanned image

1 segments. The first and second scanned image segments can then be automatically
2 compiled into a single scanned image. In this way a user is not required to manually
3 assemble a plurality of scanned image segments of an oversized document to obtain a
4 single scanned image of the oversized document.

5
6 While the above invention has been described in language more or less specific
7 as to structural and methodical features, it is to be understood, however, that the
8 invention is not limited to the specific features shown and described, since the means
9 herein disclosed comprise preferred forms of putting the invention into effect. The
10 invention is, therefore, claimed in any of its forms or modifications within the proper
11 scope of the appended claims appropriately interpreted in accordance with the doctrine
12 of equivalents.

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